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MASTER OF MILITARY STUDIES

TITLE:
COUNTERING THE CHINESE THREAT TO LOW EARTH ORBIT SATELLITES:
BUILDING A DEFENSIVE SPACE STRATEGY

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EXECUTIVE SUMMARY

Title: Countering the Chinese Threat to Low Earth Orbit Satellites: Building a Defensive Space Strategy

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Thesis: To counter the Chinese threat to its low Earth orbit satellites, the United States should adopt a defensive strategy focused on deterrence and recovery.

Discussion: China demonstrated their ability to employ an anti-satellite weapon when it destroyed one of its own weather satellites in 2007. While it does not publish a public national military strategy, several Chinese military authors advocate the use of anti-satellite technologies as an asymmetric weapon to counter the superior conventional capabilities of the United States. Towards this aim, China has developed both kinetic and non-kinetic weapons along with associated supporting infrastructure to target United States low Earth orbit satellites. The United States currently has little capability to defend against an attack on its satellites. As an initial step, the Department of Defense established the Operationally Responsive Space program to address emerging threats. The United States should use current, primarily commercial, technologies to increase its Space Situational Awareness, develop flexible and rapid launch platforms, field small satellites, decrease its dependence on space systems, defend against high-altitude nuclear explosions, and execute institutional changes. Done with transparency, these changes should deter China from employing its anti-satellite weapons. If deterrence fails, these same changes will also enable the United States to rapidly reconstitute its space systems. As a long-term effort to counter the Chinese threat, the United States must work with China to make it an active stakeholder in space activities; collateral damage from anti-satellite weapons would then threaten China and deter them from using anti-satellite weapons. These recommendations will also help protect United States satellites from other adversaries, accidents, and natural phenomena.

Conclusion: The United States can use currently available technologies to quickly build deterrence to China's anti-satellite threat to low Earth orbit satellites. These recommendations will also enable the United States to operate its satellites through an attack and rapidly reconstitute its constellations.

DISCLAIMER

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Preface

Although exposed to both offensive and defensive counterspace activities throughout my career as an Air Force space operator, I have observed a disproportionate focus on the offensive. Defensive efforts have generally been reactive rather than proactive, potentially leaving the United States vulnerable to an opportunistic adversary or natural event. Recent events have highlighted the need to protect the United States' space capabilities: Iraq's use of GPS jammers, China's destruction of an aging weather satellite, the collision between a Russian military satellite and Iridium commercial satellite, and the resumption of the Russian anti-satellite program. The United States must develop a defensive strategy that proactively employs capabilities that will deter adversaries and, if necessary, enable rapid recovery. Developing a strategy to counter China's low Earth orbit anti-satellite weapons is merely a starting point. Threats, man-made and natural, will continue to grow and so must our ability to protect our space assets.

I would like to thank Dr. Peter L. Hays, Senior Policy Analyst at the National Security Space Office, for providing a plethora of research resources which I would not have otherwise found. I would also like to thank Dr. Shibuya for his accelerated schedule, greatly helping to offset my just-in-time writing process. Finally, and most importantly, I must thank my wife for supporting my efforts and enduring my chaotic methods of organizing my research materials.

ACRONYMS

AEGIS	ship-based radar and weapon system
AFDD	Air Force Doctrine Document
BX-1	Chinese co-orbital satellite, "*Companion Satellite*"
DF-21	Chinese ballistic missile
DoD	Department of Defense
F-15	US air superiority fighter aircraft
FY-1C	Chinese weather satellite
GEO	geostationary orbit
GPS	Global Positioning System
HANE	high-altitude nuclear explosion
HEO	highly elliptical orbit
ISR	intelligence, surveillance, and reconnaissance
ISS	International Space Station
JP	Joint Publication
KKV	kinetic kill vehicle
L-1011	widebody jet aircraft
LEO	low Earth orbit
MEO	medium Earth orbit
ORS	Operationally Responsive Space
SC-19	Chinese direct-ascent anti-satellite weapon
Shenzou-7	Chinese manned spacecraft
SSA	space situational awareness
SSN	space surveillance network
STRATCOM	Strategic Command

> Let's say that nation [China] were to attack our satellites. With a robust capability, you could essentially deny a lot of the benefits and most of the satellites that we rely on in low Earth orbit in very short order. I'm talking not a week; I'm not talking days; I'm talking hours.[1]
>
> General Kevin Chilton
> Commander U.S. Strategic Command

When China destroyed its own aging weather satellite with a direct-ascent anti-satellite weapon on January 11, 2007, China demonstrated its will and technical competence to challenge the United States' superiority in space. China has not limited its anti-satellite program to direct-ascent capabilities but is pursuing a range of options from ground-based lasers to co-orbital satellites. China's anti-satellite program is designed to hinder the United States' force projection capability in the western Pacific. Without the essential meteorological, intelligence, surveillance, and reconnaissance (ISR), and remote sensing capabilities provided by low Earth orbit (LEO) satellites, the United States' ability to dominate China in a conventional war would be diminished. (See the Appendix for a description of different orbital regimes.) The United States, however, possesses little capability to respond to the growing Chinese threat to LEO satellites. To counter this threat, the United States should adopt a defensive space strategy focused on developing procedures and capabilities to deter Chinese action and, if necessary, recover from an attack.

This paper initially presents the overall Chinese military strategy as prelude to discussing Chinese counterspace strategy. It then describes the various anti-satellite weapons China has developed to attack low Earth orbit satellites. Next, it discusses current US military space doctrine. After framing the space strategy, the paper presents several implementation proposals that use currently available technologies and new procedures and policies.

CHINESE MILITARY STRATEGY

While China does not publish an overarching stated grand strategy equivalent to the US *National Security Strategy, National Defense Strategy,* or *National Military Strategy*, analysts theorize that China's strategic modernization is focused on three main objectives: regime survival, dominance of the Asia-Pacific Theater while growing its worldwide influence, and prevention of Taiwanese independence.[2] Across these objectives, China sees the United States as its principal strategic adversary and follows a military strategy of anti-access/area denial to prevent increasing US involvement in the Asia-Pacific region. China acknowledges that it cannot compete on an equal footing with US military capabilities and so must pursue asymmetric capabilities to counter US force projection in the region.[3]

CHINESE COUNTERSPACE STRATEGY

Analysis of US military operations since the Persian Gulf War in 1991 identified the high reliance of US forces on satellite systems. China believes that it can deter US participation in a conflict by preemptively attacking satellites, thus denying services essential to US force projection. If deterrence fails, these attacks would then significantly diminish military capabilities to the point that conventional Chinese forces would then be on an equal footing with US forces.[4] Additionally, China believes that anti-satellite capabilities provide national prestige and demonstrate the attributes of a world power.[5]

Despite the worldwide acknowledgement of China's recent tests, China's anti-satellite program can be characterized by a lack of transparency and conflicting public messages. In the immediate aftermath of the January 2007 test, Chinese officials provided a mixed public response that was several weeks late, indicating a lack of coordination between the civilian government and the People's Liberation Army who controls the anti-satellite program. While the civilian government likely approved the program, they probably did not fully understand the international implications of the test. Further, the aggressive anti-satellite program counters China's public calls for a global ban on space weapons.[6]

The threshold for Chinese use of anti-satellite weapons is hard to determine with certainty, although several Chinese military writers advocate using anti-satellite weapons preemptively to prevent the United States from entering a conflict. Colonel Li Daguang in 2001's *Space War* states that "the offensive capability in space should, if necessary, be capable of destroying or temporarily incapacitating all enemy space vehicles that fly above our sovereign territory."[7] This view directly threatens LEO satellites that periodically pass over China and contradicts international law which permits "unimpeded satellite overflight of other nations through space."[8] Colonel Li Daguang further postulates that development of anti-satellites must be conducted covertly: "construction of such a unit [space force] should be carried out secretly by keeping a low profile."[9] Colonel Yuan Zelu argues in 2005's *Space War Campaigns* that an early use of anti-satellite weapons may preclude United States action: "[the] goal of a space shock and awe strike is [deter] the enemy, not to provoke the enemy into combat. For this reason, the objectives selected for strike must be few and precise."[10] If Chinese anti-satellite weapons are not used at the outset of a conflict, they can be quickly negated by US precision strikes against launch sites and command and control centers. Based on the intended use of anti-satellite weapons, the lack of transparency, and Chinese writings, the United States must assume a Chinese anti-satellite strike at the outset of conventional hostilities, rather than being withheld until later, and thus must build an effective defensive capability to deter and recover.

CHINESE ANTI-SATELLITE WEAPONS

In support of its counterspace strategy, China is pursuing a variety of kinetic and non-kinetic weapons to either destroy or negate the United States' LEO satellites. The kinetic method to deny satellite services is to destroy a satellite either by launching an interceptor directly at it or maneuvering another satellite to collide or explode near the target satellite. Both the direct-ascent and co-orbital weapons require a launch infrastructure. Alternately, China could use a ground-based non-kinetic weapon, such as a laser or jammer, to either temporarily deny satellite services or permanently damage the satellite. Common to all preceding anti-satellite weapons, China requires a mechanism to identify and track enemy satellites. Finally, China has the option to use nuclear weapons against low Earth satellites.

Direct-ascent Weapons

The most renowned component of the Chinese anti-satellite program is their direct-ascent capability where a maneuvering kinetic kill vehicle (KKV) is launched to intercept the target satellite. Once near the target satellite, the KKV uses onboard sensors and maneuvering capability to guide it to the target, where the impact destroys the satellite. The most recognized success of Chinese anti-satellite development was the 2007 destruction of a Chinese FY-1C weather satellite by the SC-19 direct-ascent weapon. The Chinese demonstrated their technical competence by not altering the orbit of the FY-1C which would have improved chances of impact by maximizing time the available for KKV acquisition and maneuver.[11]

China immediately faced international criticism over the SC-19 test due to the large amount of orbital debris created. The resulting collision destroyed the FY-1C satellite and increased the low earth orbit orbital debris count by over 10%.[12] Due to the location of the target satellite in a higher portion of the LEO regime, the debris will take decades to degrade, increasing the potential for collisions with other LEO satellites. The United States has acknowledged the movement of satellites to avoid debris caused by the test.[13] The likely negative reaction by other space faring nations may have contributed to China's decision not to announce the test before the launch.

Co-orbital Weapons

Not as widely known as direct-ascent weapons, the co-orbital anti-satellite weapon is just as lethal and can be harder to detect and protect against. While a co-orbital weapon could contain explosives, its primary kill mechanism is to collide with the target satellite. China demonstrated the ability to execute a co-orbital anti-satellite attack when it launched the BX-1, *Companion Satellite*, from the Shenzhou-7 spacecraft on September 27, 2008.[14] Upon deployment, the BX-1 maneuvered around the Shenzhou-7, taking pictures of the host spacecraft. After the return of the Shenzhou-7, the BX-1 remained in orbit demonstrating co-orbital maneuvers. This act demonstrates that China has passed any anti-satellite capability achieved by the Soviet anti-satellite program.[15]

Co-orbital weapons have advantages over the direct-ascent weapons. The co-orbital can be placed into a holding orbit and wait to attack, increasing the likelihood of surprise. Further, the co-orbital satellite allows China to strike satellites that may not come into range of its direct-ascent capability. Co-orbital weapons can also be launched from a host spacecraft, like the BX-1 on Shenzhou-7. The United States would find it difficult to determine the presence of a small parasite satellite on the host satellite.

Of particular concern was the timing of the BX-1 test. The Chinese launched the BX-1 in close proximity to the International Space Station (ISS) and provided no warning. Although the BX-1 did not endanger the ISS, a malfunction could have raised concerns for the ISS crew. With adequate notification the ISS crews could have prepared contingency plans. The location of the test, however, ensured that the international community would take notice of the achievement. While the Chinese claim peaceful intentions for the BX-1, its dual use applicability easily makes this an effective anti-satellite weapon. The lack of transparency further clouds the true intentions of the test. Unless China notifies the United States of its actions, many of these tests could go unnoticed. The United States cannot afford to believe the stated Chinese intentions and must develop its defense as if the BX-1 is the precursor to an operational anti-satellite weapon.

Supporting launch capabilities

To support their anti-satellite program, the Chinese are seeking to diversify their launch capabilities. Chinese space literature advocates developing ship and submarine-based anti-satellite launch platforms.[16] Both of these options allow China to launch from almost any location on the world's oceans. If developed, China could strike satellites that may not be targetable from mainland China due to orbital constraints with direct-ascent weapons. Sea-based platforms also provide an opportunity to conduct synchronized operations and strike multiple targets around the world simultaneously. Further, sea-based platforms complicate US intelligence efforts by forcing limited surveillance assets to monitor more launch areas. Lastly, dispersed sea-based launch facilities would complicate targeting if the United States decided to actively strike Chinese launch facilities as part of its defensive strategy. The Chinese favor the ship-based solution due to supporting radar systems on board which aid targeting, a capability lacking on a submarine.[17]

Ground-Based Lasers

Although not likely to completely destroy a satellite like the direct-ascent or co-orbital weapons, China has an extensive laser anti-satellite program capable of preventing use of LEO satellites. In September 2006, the director of the National Reconnaissance Office acknowledged that a Chinese ground-based laser actively tracked and engaged a United States satellite.[18] Depending on the power of the laser, effects can range from the temporary blinding of a sensor such as a camera to disabling a critical satellite component. Ground-based lasers are limited in that they have to be in view of the satellite and, if attacking a sensor, must be aligned with that sensor. However, using a laser may not cause the same reaction from the United States because if properly applied, no permanent destruction is caused to the satellite. The Chinese may see this as a deterrent in a smaller scale scenario. China could expand the utility of its laser program by deploying them on ships, further complicating US countermeasures.

Tracking Capabilties

The preceding anti-satellite capabilities would not be possible without effective space surveillance to allow targeting of enemy satellites. The Chinese had the luxury of accurate tracking data on their FY-1C for the SC-19 test; however, they need a capability to attain the same level of coordinates on enemy satellites.[19] China has aggressively pursued a program of developing radar sites and telescopes to build targeting information. In addition, open source information on US satellites is readily available online, greatly aiding the Chinese targeting solution.[20]

ADDITIONAL ANTI-SATELLITE CAPABILITIES

By virtue of its nuclear and ballistic missile programs, China has the inherent capability to detonate a nuclear weapon in LEO as an attack mechanism. China's use of a high altitude nuclear explosion (HANE) is less likely than the previously mentioned anti-satellite weapons. However, China may consider its use in a full-scale war. In addition to the immediate electromagnetic pulse, the detonation would create a belt of persistent radiation trapped by the Earth's magnetic field causing early failure of electronics as satellites pass through the nuclear debris.[21] A 2007 Defense Threat Reduction Agency briefing stated that a single HANE "could disable – in weeks to months – *all* [low earth orbit] satellites not specifically hardened to withstand radiation generated by that explosion."[22] While this course of action would certainly inhibit US military capabilities, it would also create significant collateral damage by affecting all countries with interests in low earth orbit. "The extent to which China's leaders have thought through the consequences of nuclear use in outer space…is unclear."[23] While the use of nuclear weapons as an anti-satellite weapon is unlikely, it is a possibility that should be planned for.

Finally, China has advocated the use of conventional weapons and special forces to attack space-related ground sites such as tracking radars and monitoring stations.[24] While Chinese forces would likely not be able to attack the primary command and control sites within the continental United States, they could attack the numerous US ground stations around the world and degrade the ability to monitor friendly and enemy space assets.

UNITED STATES DEFENSIVE MEASURES

In response to the credible and expanding Chinese anti-satellite threat, the United States must adopt a defensive space strategy that can deter Chinese actions and then also recover from an attack. Some within the United States government, notably Senator Jon Kyl, have advocated an offensive deterrence strategy to counter the Chinese anti-satellite threat, creating weapons that would not only attack Chinese satellites but also anti-satellite systems.[25] This policy, however, would in effect start a space arms race, a costly proposition with many high dollar systems competing for the defense budget. Offensive kinetic anti-satellite weapons, whether direct-ascent or co-orbital, can create a significant debris field that could indiscriminately damage friendly satellites and ultimately hurt the United States more than China. The United States abandoned its Cold War kinetic anti-satellite program after a test where an F-15-launched missile destroyed a satellite and created a LEO debris field that took over 20 years to decay.[26] However, the United States demonstrated its ability to rapidly reconstitute its direct ascent anti-satellite capability when it launched a modified Standard Missile-3 from the USS Lake Erie and destroyed a malfunctioning satellite before it could reenter and possibly impact a populated area.[27] Although the United States engaged the satellite at the lower portion of the LEO regime to minimize orbital debris and provided timely notification to the international community, China criticized the operation as threatening to space security.[28] This reaction supports the idea that pursuing an offensive anti-satellite program could drive a space arms race. Finally, in an anti-satellite exchange, China currently has much less to lose. China would be much less reliant on space systems to operate in a conflict.

The September 2008 Council on Foreign Relations Report *China, Space Weapons, and U.S. Security* argues that US policy does not provide a framework to address counterspace matters. The high cost of maintaining space dominance compared to the relatively low cost to attack that dominance favors a deterrence-based strategy.[29] The Council endorses a comprehensive approach to dealing with the Chinese counter space threat: policies that focus on stability, deterrence, escalation control; an in-depth layer approach; reduce incentives to and capability of adversary to attach space systems; and increased warning time to enable defensive actions.[30] In developing capabilities, the United States should consider their contribution to stability and deterrence while incorporating a wide spectrum of defensive capabilities.

Commander John Klein proposes that the United States develop a comprehensive defensive strategy to ensure access to "celestial lines of communication."[31] He argues that past space strategies were overly focused on the offensive due to the influence of strategists like Mahan, Douhet, and Mitchell.[32] Recognizing that defensive measures assure access to and use of space, the United States through policy and action must focus on defensive strategies. Properly developed space strategies should provide "a measure of self-defense against a surprise attack, control over the escalation of a conflict, and minimize the most devastating enemy counterattacks."[33] The aforementioned reasons support a focused defensive strategy that will deter a Chinese attack and recover capability if deterrence fails.

Joint Publication (JP) 3-14, *Space Operations*, highlights the increasing dependence by the military on space: "Space capabilities are essential to overall military mission accomplishment, provide the advantages needed for success in all joint operations, and support the principles of war."[34] The publication also states that reliance on space creates vulnerabilities that can be exploited by adversaries. To prevent exploitation, the United States must ensure current military capabilities "remain protected and must constantly watch for the next space threat to ensure US military dominance in space utility."[35]

JP 3-14 broadly proposes a framework to address these vulnerabilities. The document divides US space operations into four mission areas: space force enhancement; space support; space control; and space force application. Within these mission areas, space control ensures freedom of action for friendly space forces. Two components of space control are defensive space control and space situational awareness. Defensive space control "is used to protect space capabilities and is based on protection and defensive prevention measures." Space situational awareness supports defensive actions by "characterizing the space capabilities operating within the terrestrial environment and space domain."[36]

The publication fails to adequately address a key piece of a potential defensive strategy: space support. "Space support includes spacelift operations, satellites operations, and reconstitution of space forces."[37] At first glance, these tasks may not be considered as defensive in nature, but they should form a key piece of a comprehensive space deterrence strategy. Even with the best defensive efforts, defending all space assets against direct-ascent and co-orbital weapons would be difficult, making an emphasis on reconstitution a necessity. Although JP 3-14 advocates developing "ability," it seems to shy away from a comprehensive approach involving space support as demonstrated with its statement that "development and deployment of replacement capabilities could take a year or more." [38] However, a defensive strategy that combines existing technologies with updated policies and procedures can be implemented faster than current Department of Defense (DoD) plans and programs.

0PERATIONALLY RESPONSIVE SPACE

The United States has taken some initial steps to improve its defensive capabilities. The DoD stood up the joint Operationally Responsive Space (ORS) Office on May 21, 2007 at Kirtland Air Force Base, New Mexico. The ORS effort seeks to meet emerging warfighter needs with new space capabilities. Ron Sega, DoD executive agent for space, stated that efforts will focus on the "ability to launch, activate and employ low-cost military-useful satellites, provide search capability, reconstitute and augment existing capability, while providing timely availabilities of tailor-made, unique capabilities."[39] Further, the DoD's *Plan for Operationally Responsive Space* highlighted the need to increase "situational awareness and adaptability to the threat, as well as an ability to evolve the total suite of space capabilities to address emerging threats in new ways."[40] The Commander of United States Strategic Command (STRATCOM) detailed three efforts vital to execute the plan: rapidly develop technological and operational innovations, rapidly modify or supplement existing systems to increase capabilities, and rapidly reconstitute space systems when necessary to maintain capability.[41] Initial focus on capabilities will be on ISR and communication satellites, improvement of space situational awareness, rapid launch capabilities, and command and control.[42]

The ORS effort will use a three tier capability approach to meet warfighter needs. Tier-1 implements activities immediately-to-days using existing or on-orbit systems. Tier-2 utilizes field-ready systems in days-to-weeks to provide rapid exploitation, augmentation or reconstitution of space capabilities. Finally, Tier-3 solutions take months-to-one year to satisfy needs while capabilities are modified or developed and then deployed.[43]

The ORS implementation timeline envisions eight tactical satellite demonstrators through fiscal year 2013. As of January 2009, two demonstrators have been launched with the third delayed from a scheduled spring 2009 launch due to technical issues. The program timeline also includes tests of operational employment and integration, command and control, and launch vehicles. The ORS program office recently purchased the first three launch vehicle specifically procured for ORS with launches scheduled for 2010 and 2011. Finally, the DoD expects the "Chiliworks" facility at Kirtland Air Force Base, which will focus onTier-2 satellite fielding, to be fully operational by 2015.[44]

While there are other ongoing efforts within the Intelligence Community and the DoD[45], ORS provides a good starting point for implementation of recommendations within this paper. The ORS plan identifies the need for both anticipatory and reactive elements. ORS planners should focus on the Chinese threat to build capabilities to fit within the Tier-1 and Tier-2 categories. The conflict with China would have to extend past a year to make use of Tier-3 capabilities. The United States must anticipate Chinese actions and have field-ready systems ready for either preemptive or immediate reactive use. Field-ready systems would provide a credible defensive deterrent against existing and likely Chinese offensive anti-satellite actions.

PROPOSED DEFENSIVE ACTIONS

The United States can choose from a wide variety of options to develop a defensive strategy to counter the Chinese threat to LEO satellites. The comprehensive approach should address space situational awareness (SSA), preplanned satellite actions, launch capability, small satellites, decreased dependence on space systems, nuclear explosion protection, institutional changes, transparency, and engagement.

Space Situational Awareness

Improving SSA is essential to the success of this strategy. The United States must have a comprehensive knowledge of all objects in orbit. Although the United States maintains a significant Space Surveillance Network (SSN) network, it lacks coverage in key areas and the capability to comprehensively predict the orbits of all objects in space; the February 10, 2009 collision between an Iridium commercial satellite and a Russian military satellite caught the SSN by surprise.[46] The United States could build more fixed ground sites, but this would be limited by host country permissions and fiscal constraints. As a near term improvement to coverage, the United States should leverage the US Navy's AEGIS cruiser and destroyer-based radars into its SSN. The AEGIS radar highlighted its space surveillance capability when it tracked a decaying US satellite, enabling its destruction by a US anti-satellite weapon in 2008.[47] While the Navy assets need to train and execute their primary mission, they could be given alternate tasking to search and track objects in LEO. This would entail development of procedures between services. Further, integration of land and space-based missile warning sensors into the SSN would yield benefits in the event of an anti-satellite launch. Finally, the United States should continue to pursue satellite as a sensor technology, where the satellite has the ability to self-identify and report on attacks. Improved SSA also allows the United States to characterize the resultant debris field of an anti-satellite attack and thus support reactive measures that may be required by other satellites.

Intelligence

Directly related to improved SSA is a robust intelligence effort that focuses on Chinese anti-satellite activity. Indications and warning may include increased communication at tracking stations, deployment of mobile tracking stations, and fueling and dispersal of launch vehicles. Identification and reporting of Chinese anti-satellite preparations would enable execution of preemptive defensive actions by the United States.

Preplanned Satellite Actions

Establishing preplanned actions is key to deterring and reacting to an anti-satellite attack. While the time from launch to impact for the SC-19 is on the order of minutes, intelligence of an impending launch can lengthen the timeline for taking preemptive defensive actions. While limited on-board fuel prevents large orbital maneuvers, a one-time small change to a satellite's orbit is possible. These orbital maneuvers must be executed before the launch of the anti-satellite weapon. Changes in orbit will produce a discrepancy between the anticipated satellite location and the final satellite tracking just prior to launch. The inconsistency may cause the Chinese to doubt the quality of their data and delay the launch as they develop new orbital tracking data, thus opening a window for additional US actions to prevent a launch. However, if the Chinese did decide to launch without updating their data, the slight change in orbit may cause the anti-satellite weapon to miss. These same procedures would also be effective against ground-based anti-satellite weapons; a maneuver could lead to a laser missing the target.

Having preplanned actions ready to execute provides United States planners another option. If a conflict looks to be inevitable, they could decide to rapidly execute minor maneuvers across satellite constellations. While not only complicating the Chinese targeting process, this could serve as non-destructive shot across the bow. If the conflict escalates into a conventional war, the single maneuver may buy the United States enough time to execute a kinetic strike that would dismantle the Chinese anti-satellite program. The importance of these strikes would move the priority high on the targeting list. Here again, intelligence is a key enabler. Targets must be accurately located, vetted, and updated to enable quick strikes on the anti-satellite targets.

Variable and Rapid Launch Capability

The current United States Department of Defense launch complex does not have the capability to rapidly replenish satellites in the event of destruction. Launch preparation and execution can take weeks to months. The United States must adopt rapid and flexible commercial launch technologies.

Of at least equal importance to having a rapid launch capability is a launch system that deploys satellites from varying locations. When launched from the traditional space ports of Cape Canaveral and Vandenberg Air Force Base, China can easily monitor the launch and quickly determine the initial orbit and possibly satellite type. Having a capability that can unpredictably launch from unmonitored locations will delay China's ability to track and identify United States satellites, greatly inhibiting their ability to target satellites. This capability could be sea-based, where monitoring by an adversary is more difficult. The capability could also be airborne, like the Pegasus program which has successfully launched satellites using an L-1011 aircraft from California, Virginia, Florida, the Canary Islands, and the Marshall Islands.[48]

Small Satellites

The United States must also make a move towards smaller satellites that use a common bus and architecture. A single launch vehicle could then deploy multiple small satellites, allowing the rapid establishment of a new constellation at the beginning of a conflict or replenishment of an old one. China would then face a dilemma as to which satellites they would attack. If China does decide to attack, the impact would be proportionately smaller because they would take out a lesser percentage of the constellation. The Iridium collision demonstrated the ability of a large constellation to absorb the loss of single satellite with minimal degradation.[49] Having numerous small satellites ready to launch can also lesson the need to perform defensive orbital maneuvers, as they can be quickly replenished. Finally, small satellites are inherently harder to track whether by radar or optical telescopes. While a requirement for large satellites remains; small satellites will help protect and complement the large satellites.

Key to developing small satellites is a common command and control (C2) network regardless of function, rather than today's stovepiped C2 that are unique for each satellite type. A common bus and C2 system can also support small satellites by relying on a cross-linked network to control satellites and download mission data from a central location rather than on ground stations distributed around the globe.

Decreased Dependence on Space Systems

The United States must decrease its dependence on space systems, making attack on satellites a less appealing target. United States military forces should have weapons and procedures that can function with or without satellite support. For example, high altitude unmanned aerial vehicles can and should complement, and potentially replace, the LEO satellite ISR mission.

Countering High-altitude Nuclear Explosions

Although the possibility of a HANE may be remote, defense against the long term radiation effects must focus on hardening all future satellites against nuclear explosions. Without hardening, depending on the size of the constellation, satellite replenishment could take months and quickly exhaust satellite spares even with rapid reaction launch capabilities. Building satellites to withstand the nuclear weapon radiation effects beyond that required against the natural environment would add only 2 to 3 percent to total satellite cost.[50] Consideration may be given to forgoing hardening for satellites designed for a short (days to weeks) lifetime; one should consider the radiation from a nuclear explosion may remain for up to two years, precluding the launch of non-hardened satellites into the affected orbital regime.[51] While some government low-earth orbit satellites are already hardened, the United States should harden all future satellites.

Institutional Changes

Changes must be properly incorporated into the DoD infrastructure to be effective. All aspects of doctrine, organization, training, materiel, leadership and education, personnel and facilities must be examined. Additionally, the changes must work across many organizations within the DoD and throughout the United States government. For example, STRATCOM should run comprehensive anti-satellite exercises that incorporate all applicable services and agencies, from the satellite operator to the end user.

Transparency

The above actions may deter China from further pursuing its anti-satellite programs, but only if executed in a transparent manner. Systems must be fully trained and tested; the United States must overtly demonstrate its capability to rapidly deploy satellites. China must be made fully aware of US capabilities to effectively counter its anti-satellite weapons. China may then realize that its actions will have minimal effect on US military capabilities.

Engagement

Beyond using a military response to protect government satellites, the United States should consider a holistic approach to China's anti-satellite capabilities by using the other elements of national power: diplomatic, information, and economic. China's current reliance on space is minimal when compared to the United States. China can therefore afford to use anti-satellite weapons against the United States. Increased Chinese reliance on space would provide significant deterrents to Chinese use of certain weapons such as direct ascent, co-orbital, and nuclear, since collateral damage from these weapons would affect China. First, the United States should engage on Chinese proposed treaties limiting space weapons. Next, the United States should work to build Chinese economic dependence on space systems, while taking appropriate measures to limit technology transfer. With a gap between the Space Shuttle and Ares launch vehicles, an opportunity exists to bring China in as a partner on the International Space Station by providing equipment launch services. Working with China to build its reliance on and participation in space activities will help build deterrence to the use of anti-satellite weapons; the collateral effects would harm its own interests.

ADDITIONAL RECOMMENDATIONS

While this paper focuses on LEO satellites, the same rigor must also be applied to medium Earth orbit (MEO), highly elliptical orbit (HEO), and geosynchronous (GEO) orbit satellites. Although current direct ascent anti-satellite capability can only reach LEO, China's ballistic missile and space launch vehicles could reach higher orbits. Additionally, China has orbited GEO satellites which could already be carrying co-orbital anti-satellite weapons. China has expressed interest in combating the MEO GPS system through both kinetic and non-kinetic attacks.[52] China is also actively developing jamming capabilities to combat United States military communications satellites found predominately in GEO.

Additionally, the proposed defensive measures will do more than support deterrence against China. Numerous nations will seek to emulate Chinese actions with kinetic and non-kinetic options. In response to the recent anti-satellite activity of China and the United States, Russia announced the resumption of its anti-satellite weapons program.[53] Ground-based actions such as jamming are within the realm of many nations and individuals. One only need look at the hijacking of the HBO satellite signal by "Capt Midnight" as an example of a single individual being able to steal a satellite transponder, in effect jamming the intended signal.[54] Further, proliferation of nuclear weapon and ballistic missile technology make the use of a HANE attractive to a rogue nation or terrorist nation that has little reliance on space capabilities. The Defense Threat Reduction Agency suggests this scenario as a possible last act of defiance by North Korean forces facing defeat.[55] Lastly, these measures can be used to combat natural phenomena, such as a meteor shower or solar storms that can damage satellite systems. "A strategy that ensures access to and use of space is useful in times of peace just as in times of war, since space systems that provide critical services may fail or become inoperative in the absence of hostile action."[56]

Finally, the United States must not stop at applying these recommendations merely to military satellites. While government satellites are critical in a conflict, commercial satellites in all orbital regimes have become an integral part of military operations to include weather, imaging, and communications. Although tightly tied to the world economy, China could decide to expand its anti-satellite program to attack the economic interests of the United States. While commercial satellites companies typically incorporate protective measures against natural threats, the United States government should share best practices and provide incentives to commercial entities to protect themselves against human threats. The government could do this through requirements to obtain licensing or guaranteed government contracts to companies that comply.

CONCLUSION

> The fundamental U.S. security interest in the wake of China's 2007 anti-satellite test should be deterring China and others from attacking U.S. assets in space, using both a combination of declaratory policy, military programs, and diplomacy, and promoting a more stable and secure space environment.[57]
>
> Council on Foreign Relations

The United States government requires a comprehensive plan to counter the threat to its LEO systems posed by Chinese anti-satellite weapons. Failing to protect these key satellites would severely degrade US military capabilities in a conflict with China. The United States should rely on a defensive space strategy to deter Chinese anti-satellite actions. The strategy must include robust space situational awareness, preplanned actions, small satellites, rapid and variable launch capability, decreased dependence on space systems and institutional changes. In total, these actions would complicate the ability for Chinese anti-satellite weapons to easily strike US assets while providing the means to operate through an attack and then reconstitute lost capability. The DoD's ORS effort can be used as springboard, but must be accelerated to meet the rapidly emerging threat. Finally, its growth as a space faring nation may eventually be the best deterrence against a Chinese attack on United States satellites. However, the actions outlined in this paper can also be used to counter threats from other nations or natural phenomena. A rapid comprehensive defensive deterrence approach most effectively counters the Chinese threat and meets Presidential guidance to establish "contingency plans to ensure that U.S. forces can maintain or duplicate access to information from space assets and accelerating programs to harden U.S. satellites against attack."[58]

APPENDIX A: Orbit Descriptions[1]

Footprint: The area on the Earth's surface within the field of view of a satellite's antennas or sensors.

Geostationary Orbit: A type of GEO, geostationary satellites appear to remain fixed in the sky and provide continuous coverage of a specific area of the Earth. A geostationary satellite's footprint covers approximately one-third of the earth between the latitudes of 70 degrees north and 70 degrees south. Geostationary orbits are commonly used for communications, weather, and surveillance.

Geosynchronous Orbit (GEO): Satellites in GEO operate at an altitude of 35,786 kilometers and complete each orbit in one day. Although GEO satellites stay generally over the same spot on the Earth, they do not remain stationary relative to a ground observer.

Highly Elliptical Orbit (HEO): HEO satellites move in an elliptical orbit with the closest point to the Earth at about 400 kilometers and the furthest point at approximately 40,000 kilometers. HEO permits extended coverage over parts of the Earth when in the furthest portion of the orbit. The Russians have used HEO extensively to provide satellite coverage over northern latitudes not supported by geostationary orbits.

Low Earth Orbit (LEO): LEO satellites generally have a maximum altitude of approximately 850 kilometers. Because of their close proximity to the Earth, LEO satellites are well suited for observation, environmental monitoring, small communication satellites, scientific payloads, and manned spaceflight. However, LEO satellites are in view of a ground user for short periods of time as the satellite passes overhead and possess a small footprint. The maximum time a LEO satellite will be in view is approximately 20 minutes, and may require several orbits before it passes into view again. Finally, maintaining constant communication with LEO satellites requires either a worldwide network of ground stations or a constellation of relay satellites.

Medium Earth Orbit (MEO): MEO satellites are located above LEO and below GEO. MEO satellites can be in view of an observer on the order of a few hours. MEO satellites also possess a larger footprint than LEO satellites. MEO is typically used for communications satellites.

Semi-Synchronous Orbit: Semi-synchronous satellites orbit at 20,200 kilometers and are considered to be in a MEO. Semi-synchronous satellites orbit the earth twice a day. Due to the Van Allen radiation belts, satellites in a semi-synchronous orbit must be hardened to survive high doses of radiation. The United States' GPS navigation satellites use a semi-synchronous orbit.

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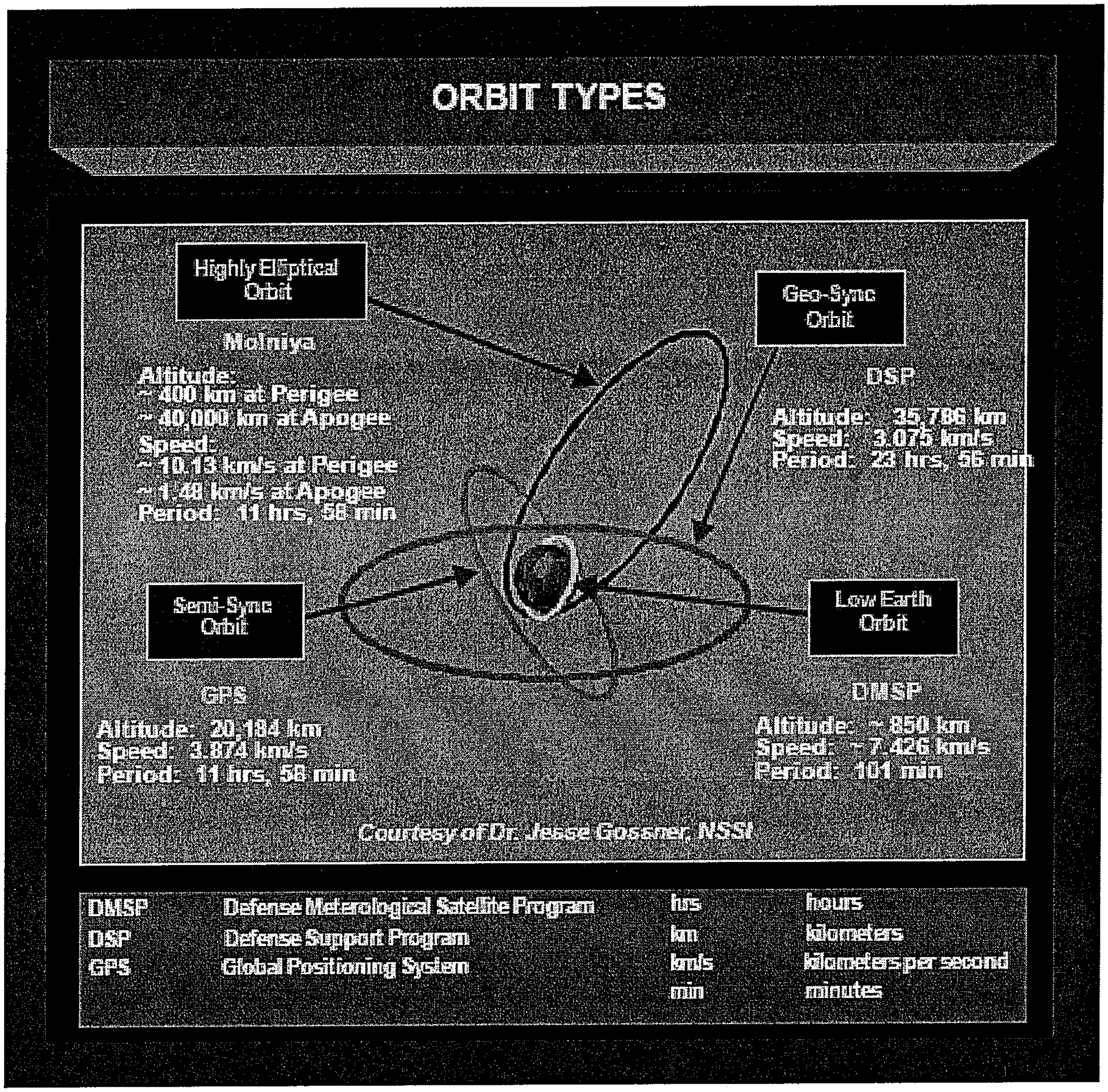
[1] All definitions compiled from *U.S. Military Space Reference Text* and JP 3-14, *Space Operations*.

APPENIX B: Orbit Types Figure



Source: JP 3-14, *Space Operations*, H-5.

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